The Antarctic Vortex Transport and Mixing Test

Purpose: This diagnostic examines a model's ability to produce and enhance the dynamical barrier to transport found at the edge of the lower stratospheric Antarctic vortex in spring. The presence of a realistic vortex edge is important for containment of chemical perturbed air inside the vortex and thus the simulation of O_3 loss.

Required data set: This test uses 12 years of HALOE CH_4 and temperature measurements between 44^oS-80^oS from September 1 through November 30. Data from 2002 is excluded because of the unusually early vortex breakup. HALOE temperature measurements are used to interpolate the CH_4 observations to isentropic surfaces. Probability distribution functions are calculated on the two potential temperature surfaces for 6 space-time bins: for each of the 3 months (Sep, Oct, Nov), there is one bin each for the latitude ranges 44-60^oS and 60-80^oS. Because of the low interannual variability in southern hemisphere dynamics, it is feasible to combine the measurements from 12 years of observations. HALOE's sparse sampling (15 profiles around a latitude circle per day) prohibits the calculation of meaningful PDFs from a single year's data.

You may download this 'processed' data set from this web page. The data file containing HALOE pdfs was created in IDL by the 'save' command. It can be read into an IDL session using the 'restore' command. This data file contains HALOE CH_4 on seven isentropic surfaces (450, 600, 800, 1000, 1200, 1400, 1600K), although the 'official' test only includes the lowest two levels.

Analysis software: I am providing several IDL procedures that you may download for the calculation of pdfs from your model output. The routine requires model output on a regular grid. Please read the comments inside 'calc_model_pdf.pro' for more detailed instructions. This procedure calls a number of other IDL procedures, all of which are available here.

Performing the Test: For each isentropic surface, create one plot for each month that shows the PDFs for both latitude bins (model or observations). You may download a sample IDL plotting procedure and a post script file showing plots produced by this procedure.

Evaluation Criteria: For the evaluations, it is helpful to calculate the most probable value of each pdf (each altitude, each month, each latitude band). If the pdf has a choppy look to it, you might smooth it first to get the best estimate of the most probable value. Most of the evaluations you can do by a visual comparison of pdfs.

Below is a table of the 'tests' or comparisons to be made, how to grade them, and what process or feature each test evaluates. Each comparison specifies which levels should be tested, usually 450K and 600K. These tests are not orthogonal. These abbreviations are used in the table:

V_{pdf} – Vortex (60-80S) pdf
M_{pdf} – Midlatitude (44-60S) pdf
V_{mpv} – The most probable value of V_{pdf} (a mixing ratio)
M_{mpv} – The most probable value of M_{pdf} (a mixing ratio)

Comparison	Grading	Process or Feature Evaluated
1. V_{pdf} and M_{pdf} in September, 450 & 600K. There should be broad, overlapping distributions with clear separation between V_{mpv} and M_{mpv}. Greater separation at 600K. Pdfs at 600K can be weakly bimodal.	For each surface, 1 pt if the criteria of breadth and overlap are met, 0 otherwise. 1 pt if the separation of the pdfs is greater at 600K than at 450K. (3 pts total)	Vortex conditions in September
2. Change in V_{mpv}, 450 & 600K. The October V_{mpv} should be lower than it was in September. The overlap between V_{pdf} and M_{pdf} in October should have a lower minimum than it had in September.	For each surface, 1 pt if V_{mpv} is lower in Oct than in Sept. ½ pt if it is the same or no more than ~5% higher. 0 points if it is higher still. For each surface, 1 pt if the overlap minimum between the pdfs is lower in October. (4 pts total)	Vortex Development: erosion (edge sharpening)
3. Change in M_{mpv}, 450 & 600K. The October and November M_{mpv} must not be lower than they were in September. (Lower CH_4 would mean strong influence from vortex air.)	For each surface, 1 pt if M_{mpv} is the same or higher in Oct than in Sept. 0 points if it is lower. (2 pts total)	Vortex influence on midlatitudes
4. Change in V_{pdf} width, 450 & 600K. The width of the distribution should decrease from September to October.	For each surface, 1 pt if the peak narrows, 0 points if it does not. (2 pts total).	Mixing within the vortex
5. Modality of V_{pdf} in November, 450, 600, and 800K. V_{pdf} at 450 & 600K must be bimodal. V_{pdf} at 800K should look the same as M_{pdf} and be single mode). The vortex air mass should show a progression from having 'some' to 'all' midlatitude air from 450K to 800K.	For 450K & 600K, 1 pt if the V_{pdf} is bimodal, ½ pt for a single mode with a long tail, 0 points for single mode w/o a long tail, regardless of whether the mode represents vortex or midlatitude mixing ratios. 1 pt if the 800K V_{pdf} looks like the M_{pdf}. 1 pt if there is a progression from 'some' midlatitude air in V_{pdf} at 450K, to 'more' at 600K, to 'all' at 800K. (4 pts total)	Vortex conditions in November
6. Location of the high CH_4 peak of V_{pdf}, 450 & 600K in November. This peak must fit approximately under the M_{pdf} peak.	For each surface, 1 pt if the high CH_4 peak looks like M_{pdf} peak, 0 points if it does not. Also, 0 points if there is no second peak in V_{pdf} (2 pts total)	Rapid homogenization of vortex air that has peeled off

Sample Test: The file 'sample_grading.pdf' has both a figure showing HALOE and model pdfs along with text that describes the grading of the model according to the above table. The results are summarized in terms of processes that are represented well or poorly by the model.

Reference: S.E. Strahan and A.R. Douglass, "Evaluating the credibility of transport processes in simulations of ozone recovery using the Global Modeling Initiative three-dimensional model", *J. Geophys. Res., 109*, D05110, doi:10.1029/2003JD004238.

Files for download:

Instructional

Sample_vortex_test.pdf	plot of haloe and ctm for 3 months, 3 thetas, Plus a page describing the grading.

Data sets and programs

haloech4_vortextest.dat	idl saveset with 12 years HALOE CH4
model_vortex_test.dat	idl saveset with model pdfs (GSFC CTM)
plot_haloe_model.pro	idl routine to restore data sets and plot
calc_model_pdf.pro	idl routine to calculate model pdfs
pdf.pro	required idl routine
pdf_field.pro	required idl routine
gridinit.pro	required idl routine
latlonintrp.pro	required idl routine